MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 1, 2018/2019

ETM3136 – DIGITAL COMMUNICATIONS

(TE)

24 OCTOBER 2018
2.30 p.m. – 4.30 p.m.
(2 Hours)

INSTRUCTION TO STUDENTS

1. This question paper consists of 7 pages with **4** Questions only.

2. Attempt **ALL FOUR** questions. All questions carry equal marks and the distribution of the marks for each question is given.

3. Please write all your answers in the Answer Booklet provided.

Question 1

7-bit PCM encoder used to encode an analog single $m(t)$ and send the digital data with a bandwidth of 52.5kHz over optical fiber channel. The analog signal were sampled at sampling rate 50% above the Nyquist rate. Consider Figure Q1 is the frequency domain of $m(t)$, along with noise $N(f)$ interfering the signal before the sampling, where $N(f)$ has bandwidth of 5kHz.

(i) Find the minimum sampling rate, where no aliasing occurred between the samples, at the receiver side, a low-pass filter can be used to remove the sampling spectrum of the noise $N(f)$ so, we can recover the signal $M(f)$ only.

[10 marks]

(ii) Consider the measured signal-to-noise ratio (SNR) of the signal is 10dB. Is it possible to obtain error-free transmission? Justify your answer.

[5 marks]

(iii) Sketch the ideal sampled spectrum of both $M(f)$ and $N(f)$ at the minimum sampling rate calculated in section (i). The considered range is -35 kHz $\leq f \leq 35$ kHz. Label the axis.

[5 marks]

(iv) Consider the mathematical equation of the signal $m(t)$;

$$m(t) = 0.2cos(1.5f_m\pi t)$$

Where f_m is the signal baseband frequency, which is calculated in section (i). If delta modulation (DM) is used, use the minimum sampling rate calculated in section (i) to find the step size Δ.

[5 marks]

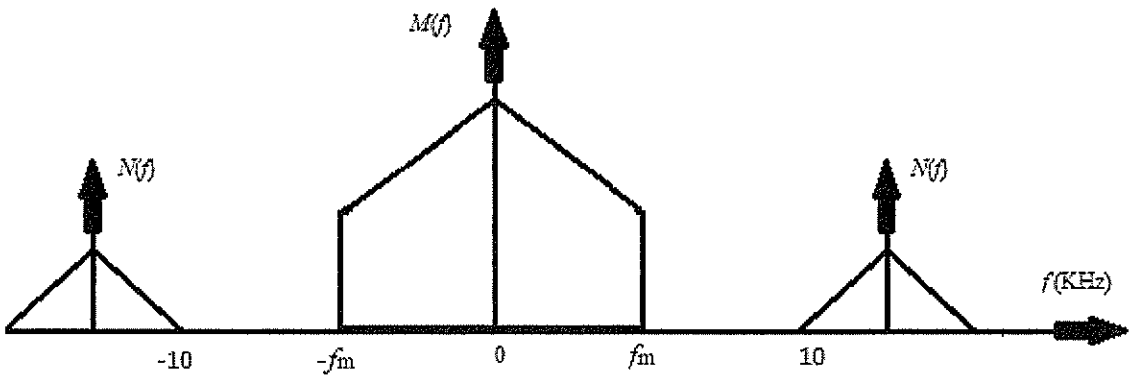


Figure Q1

Continued...

Question 2

(a) Consider TDM system accommodating eight telemetry signals, $m_i(t), i = 1,2 \ldots 8$, using PCM, each of which having a bandwidth 4 kHz. Assuming that, the maximum tolerable error in sample amplitude of the first signal $m_1(t)$, is 0.1% of the peak amplitude; for other signals, it's 0.2% of the peak amplitude. Also, the first signal is sampled at 50% over the Nyquist rate and the others at 25% over Nyquist rate. Framing and synchronizing require an additional 2% extra bits of the total data rate.

(i) Determine the minimum transmit data rate. [13 marks]

(ii) Determine the minimum bandwidth required to transmit the composite signal by 16-level PAM signalling if the system uses raised-cosine spectrum with roll of factor 30%. [6 marks]

(b) Consider a code division multiple access (CDMA) system accommodates 30 equal-power users. Each user transmits information at 5kbits/s with a direct-sequence spread-spectrum BPSK modulation signal. Calculate the minimum chip rate of the PN code in order to maintain a bit error probability of 10^{-5}. Assume that the receiver noise is negligible with respect to the interference from the other users.

[6 marks]

Continued...

Question 3

Let's assume 70km of optical fibre is used to connect central office at Melaka and an optical network unit at Seremban. The optical fibre will carry many user's data. The user's analog signal $m(t)$ is digitized at sampling rate 20000 samples/s. Then encoded by 5-bit encoder. Finally the signal modulated by high modulation technique and occupied a bandwidth 110 KHz in the optical fibre.

(i) As a telecom engineer hired to design this system, what can you do to avoid any intersymbol interference (ISI)?

[3 marks]

(ii) What is the appropriate modulation technique will you use for this digital system? Calculate the roll off factor of the Nyquist shape.

[7 marks]

(iii) Use pseudo noise (PN) sequence to spread the generated digital date for the proposed system, which is can be generated by linear feedback-shift register of length $m = 7$. A white Gaussian noise (AWGN) with a power spectral density $N_0 = 1\times 10^{-16}$ W/Hz interfered the signal. Then the secured data modulated by the same technique you chose in section (ii).

1. Name two techniques that can be used to spread the digital data. [4 marks]
2. Find the chip rate R_c [3 marks]
3. What is the jamming margin against a continuous tone jammer if the desired error probability is 10^{-9}? [8 marks]

Continued...

Question 4

Melaka state government wants to establish new an Erlang B cellular system that will cover the area of the state, which is 1700km^2. Due to the large percentages of the population (800000) is subscribed to a cellular system, the government expecting that each user makes 1 call every 1 hour with average call duration of 3 minutes. Therefore, the government decided the following:

(i) The total bandwidth should be 35MHz.
(ii) The full duplex channel bandwidth is 50kHz
(iii) Only hexagonal cells can be used with a radius 2.5km, and the cluster size is 7 cells.
(iv) The allowable probability of call blocking is 0.05

As a telecom engineer who owns a company and wants to win this project, you have to prepare your proposal and consider the following:

1. The total number of cells in the system [3 marks]
2. The number of channels per cell [3 marks]
3. The total number of channels in the system [3 marks]
4. Traffic intensity per cell for one hour [4 marks]
5. Maximum carried traffic for the whole system for one hour [3 marks]
6. The total number of users who can use the system [3 marks]
7. Percentage of population of the city who can subscribe to the cellular service [3 marks]
8. The theoretical maximum number of users who can be served at any time. [3 marks]

End of Page

Appendix I

Tabulated values of Q-function

The Q Function (Gaussian Distribution with $\mu = 0$ and $\sigma = 1$)

$$Q(a) = \int_a^\infty \frac{1}{\sqrt{2\pi}} e^{\frac{-x^2}{2}} dx \qquad Q(a) \cong \frac{1}{a\sqrt{2\pi}} e^{\frac{-a^2}{2}} \text{ for } a \geq 3$$

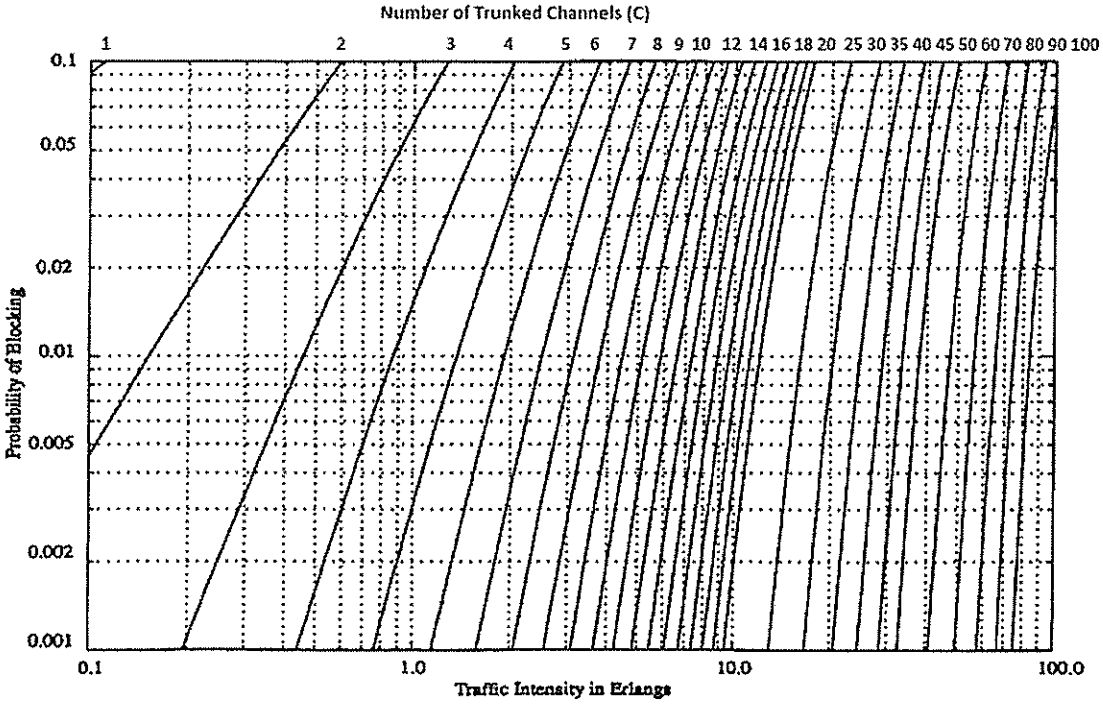
	3rd Significant Digit									
a	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.0	0.5000	0.4960	0.4920	0.4880	0.4840	0.4801	0.4761	0.4721	0.4681	0.4641
0.1	0.4602	0.4562	0.4522	0.4483	0.4443	0.4404	0.4364	0.4325	0.4286	0.4247
0.2	0.4207	0.4168	0.4129	0.4090	0.4052	0.4013	0.3974	0.3936	0.3897	0.3859
0.3	0.3821	0.3783	0.3745	0.3707	0.3669	0.3632	0.3594	0.3557	0.3520	0.3483
0.4	0.3446	0.3409	0.3372	0.3336	0.3300	0.3264	0.3228	0.3192	0.3156	0.3121
0.5	0.3085	0.3050	0.3015	0.2981	0.2946	0.2912	0.2877	0.2843	0.2810	0.2776
0.6	0.2743	0.2709	0.2676	0.2643	0.2611	0.2578	0.2546	0.2514	0.2483	0.2451
0.7	0.2420	0.2389	0.2358	0.2327	0.2297	0.2266	0.2236	0.2207	0.2177	0.2148
0.8	0.2119	0.2090	0.2061	0.2033	0.2005	0.1977	0.1949	0.1922	0.1894	0.1867
0.9	0.1841	0.1814	0.1788	0.1762	0.1736	0.1711	0.1685	0.1660	0.1635	0.1611
1.0	0.1587	0.1562	0.1539	0.1515	0.1492	0.1469	0.1446	0.1423	0.1401	0.1379
1.1	0.1357	0.1335	0.1314	0.1292	0.1271	0.1251	0.1230	0.1210	0.1190	0.1170
1.2	0.1151	0.1131	0.1112	0.1094	0.1075	0.1057	0.1038	0.1020	0.1003	0.0985
1.3	0.0968	0.0951	0.0934	0.0918	0.0901	0.0885	0.0869	0.0853	0.0838	0.0823
1.4	0.0808	0.0793	0.0778	0.0764	0.0749	0.0735	0.0721	0.0708	0.0694	0.0681
1.5	0.0668	0.0655	0.0643	0.0630	0.0618	0.0606	0.0594	0.0582	0.0571	0.0559
1.6	0.0548	0.0537	0.0526	0.0516	0.0505	0.0495	0.0485	0.0475	0.0465	0.0455
1.7	0.0446	0.0436	0.0427	0.0418	0.0409	0.0401	0.0392	0.0384	0.0375	0.0367
1.8	0.0359	0.0351	0.0344	0.0336	0.0329	0.0322	0.0314	0.0307	0.0301	0.0294
1.9	0.0287	0.0281	0.0274	0.0268	0.0262	0.0256	0.0250	0.0244	0.0239	0.0233
2.0	0.0228	0.0222	0.0217	0.0212	0.0207	0.0202	0.0197	0.0192	0.0188	0.0183
2.1	0.0179	0.0174	0.0170	0.0166	0.0162	0.0158	0.0154	0.0150	0.0146	0.0143
2.2	0.0139	0.0136	0.0132	0.0129	0.0125	0.0122	0.0119	0.0116	0.0113	0.0110
2.3	0.0107	0.0104	0.0102	0.0099	0.0096	0.0094	0.0091	0.0089	0.0087	0.0084
2.4	0.0082	0.0080	0.0078	0.0075	0.0073	0.0071	0.0069	0.0068	0.0066	0.0064
2.5	0.0062	0.0060	0.0059	0.0057	0.0055	0.0054	0.0052	0.0051	0.0049	0.0048
2.6	0.0047	0.0045	0.0044	0.0043	0.0041	0.0040	0.0039	0.0038	0.0037	0.0036
2.7	0.0035	0.0034	0.0033	0.0032	0.0031	0.0030	0.0029	0.0028	0.0027	0.0026
2.8	0.0026	0.0025	0.0024	0.0023	0.0023	0.0022	0.0021	0.0021	0.0020	0.0019
2.9	0.0019	0.0018	0.0018	0.0017	0.0016	0.0016	0.0015	0.0015	0.0014	0.0014
3.0	0.0014	0.0013	0.0013	0.0012	0.0012	0.0011	0.0011	0.0011	0.0010	0.0010
3.1	0.0010	0.0009	0.0009	0.0009	0.0008	0.0008	0.0008	0.0008	0.0007	0.0007
3.2	0.0007	0.0007	0.0006	0.0006	0.0006	0.0006	0.0006	0.0005	0.0005	0.0005
3.3	0.0005	0.0005	0.0005	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0003
3.4	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0002

$Q(a)$	a
10^{-4}	3.73
5×10^{-5}	3.90
10^{-5}	4.27
5×10^{-6}	4.43

$Q(a)$	a
10^{-6}	4.76
10^{-7}	5.20
10^{-8}	5.61
10^{-9}	6.00

Appendix II

Probability of Call Blocking in an Erlang B System



Hexagonal Cell Area = $2.598\ R^2$

Where R is the radius of the cell